

SCIENCE TO SUSTAIN SOCIETY

A Speech by Ralph J. Cicerone, President
National Academy of Sciences
Presented at the Academy's 149th Annual Meeting
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We are pleased that this year's annual meeting is in our historic building here on Constitution Avenue. As you know it has just undergone a restoration of some of its historic features and materials, a renovation of its utilities and improvements to many rooms. Here is a photograph of the NAS Council in front of the NAS Building one year ago [Figure 1, on left] when external scaffolding was everywhere. Getting the project done on time for today's meeting was a challenge, and this year's NAS Council looks happier in this second photograph from three days ago [Figure 1, on right].

For this successful project, we owe thanks to many people: to Gilbane Building Company and

Quinn Evans Architects; to Mr. Joseph Papa, who oversaw the project; to our Chief Operating Officer and Interim Executive Officer, Mr. James Hinchman; to our Chief Financial Officer, Ms. Mary (Didi) Salmon; to our Treasurer, Professor Jeremiah Ostriker; and, although she does not want me to mention her, to my wife, Professor Carol Cicerone. From helping with the original concepts and definition of the project through all phases of it, these people have been creative, practical and essential. A number of NAS members gave gifts that helped to improve the auditorium and the landscaping outside. At tomorrow's Business Meeting, I will report a little more on this project and the building.



Figure 1 NAS Council in front of the NAS Building on April 29, 2011 (left) and again on April 27, 2012 (right).

News Notes

Later this morning we will present the 2012 National Academy of Sciences Awards. This year's Public Welfare Medalist is Professor Harold T. Shapiro; it is an honor and a pleasure to have him here this morning and to recognize just a few of his many inspired and discerning accomplishments in the applications of science to the public welfare.

A few months ago, Professor Inder Verma became the Editor-in-Chief of the *Proceedings of the National Academy of Sciences*. He leads a very active group of NAS members who serve as Editors and Associate Editors of PNAS.

At the National Research Council

During the past year, we have produced a significant number of reports on major issues of the day. The reports represent the work of NAS, NAE and IOM, together with our members, NRC staff, and many external volunteers and reviewers guided by our procedures. Generally, these reports are requested by the federal government but also by states and private foundations. I want to mention just six of them that are already having public impact: a report from the Institute of Medicine, *Chimpanzees in Biomedical and Behavioral Research: Assessing the Necessity*. Very shortly after its release, NIH announced a moratorium on NIH funding of research involving chimpanzees; *Managing for High-Quality Science and Engineering at the NNSA National Security Laboratories* from our Division on Engineering and Physical Sciences; a report from our Division on Earth and Life Studies, *Uranium Mining in Virginia*, which is being used by the State of Virginia as it decides whether to lift a 30-year moratorium on uranium mining in Virginia; *America's Climate Choices* in four volumes, from the Division of Earth and Life Studies; *A Framework for K-12 Science Education:*

Practices, Crosscutting Concepts, and Core Ideas, a report that helps to create national standards for K-12 science instruction, from our Division of Behavioral and Social Sciences and Education; and from our Policy & Global Affairs Division, *Reference Manual on Scientific Evidence*, is a primary reference for judges dealing with scientific and technical evidence.

Examining these and others of our reports released in the last year or so, one sees the contributions of the individual study committee members, the value added by reviewers of each report, by the Report Review Committee, and by our program staff. Moreover, since June 2011 all NRC (and IOM) reports are now available free-of-charge electronically when they are issued. This means of wider distribution increases their potential impact. Being able to furnish requestors with free electronic copies while also selling printed copies has long been a goal but achieving it within our financial bounds required extraordinary efforts and talents of Barbara Kline Pope (who directs the National Academies Press), James Hinchman, William Colglazier and their colleagues. Also since June 2011, James Hinchman, displaying high levels of energy, intelligence and integrity, has been the Interim Executive Officer (and the Chief Operating Officer) of the NAS and NRC. At tomorrow's Business Meeting, I will introduce the NAS/NRC Executive Officer-Designate, Bruce Darling.

Federal Research Funding

During the past year, concerns over federal research funding have become more widespread and serious. I focused on these problems last year at the NAS Annual Meeting, and there will be continuing discussions during the current meeting. Prospects for federal research budgets for the coming year(s) are not clear, and we have

several challenges before us: to make a strong case for the value of this research; to prepare for very constrained funding; and to employ methods, some old and some new, to maximize the effectiveness of available funds. We want the remarkable enterprise of American science to continue — to create opportunities for students and for careers of researchers. We want to be part of the worldwide advance of science and its applications, and to lead these advances. Current prospects for federal research funding are not encouraging, and significant improvement might be years ahead, a pattern that leads to my main remarks today.

Large, Daunting Challenges

Today I want to focus on an array of societal issues and situations that are large and daunting, problems such as low levels of educational attainment; scarcity of natural resources with increasing demands for land, water, minerals and energy; and threats to public health, food security and the environment, driven by world population growth and poor governance. There are also problems arising from large numbers of disenfranchised and desperate people, from economic dislocations and from governments that seem not to be up to the tasks at hand. Some of the problems that I have in mind are evident in the U.S., others are concentrated in third-world, developing countries while still others are more ubiquitous.

On most of these problems, we are not making enough progress. In the U.S., bitter partisan disagreements are a major impediment. Worse yet, there seems to be a lack of ambition and little confidence that we can solve these problems.

Meeting human worldwide energy demands is one such challenge. Energy must be supplied within limits of cost, security and reliability, and without causing atmospheric concentrations of

carbon dioxide to increase to dangerous levels. These conditions must be met for all nations, during a period in which human population is likely to rise by perhaps two billion in the next 35 or 40 years. Simultaneously, some countries are turning away from nuclear power. Larger issues of sustainability require meeting human demands for food, fiber, transportation, education, housing and employment — without compromising the ability of future human generations to do the same. For example, consuming available resources or irreversibly harming the environment or reducing biodiversity would reduce the options of the next generations. Failure to meet all targets will lead to deprivation, retarded economic growth or to wars.

The relative success of meeting worldwide bulk needs for food must be continued and enhanced in the face of population growth, potential limits imposed by water usage, competition for land, potential limits for application of fertilizers and pesticides, some rejection of genetically modified crops, and the difficult issues of distribution. The growing challenge of monitoring and managing world fisheries has all of these dimensions and those of international governance.

There is a need to anticipate and prepare for outbreaks of communicable diseases (from natural, or from accidental or intentional origins) in 21st Century settings such as dense urban environments connected by intercontinental air travel. Failure to provide preventive public health measures, diagnostics, communication and treatments could lead to many serious cases of disease and casualties.

In many countries now, inadequate nutrition, lack of access to safe drinking water and to education lead to unnecessary misery and to disenfranchised, desperate people. Many benefits would flow from meeting these fundamental and broad needs.

A suite of specialized large challenges must be noted. Global climate change must be measured, understood and predicted well enough to permit some effective adaptation, and mitigation of human causes must be undertaken. Failure to mitigate and to adapt will diminish our ability to limit disruptions due to extreme events, for example. Eradicating specific diseases is a hope that has led to specific goals and to one success worldwide (smallpox); large challenges remain. Creating biologically derived fuels for transportation, such as biodiesel or butanol, to displace some petroleum dependence could be achieved by advances in microbial genetics and molecular biology, but large volumes of fuel are needed.

There are other major areas for which great scientific and educational progress could lead to enormous advances and they also require sustained and continuous efforts. One example is the realization of the potential of the knowledge of the human genome. Genomics and proteomics could lead not only to improved prospects for many individuals but also to better management of some aspects of health care by various private and government agents. Similarly, attaining success with nuclear fusion energy would be quite beneficial. To increase chances that we will realize goals such as these, however, requires that we in the United States make long-term commitments to scientific research in general and specifically to our public research universities, while maintaining the strength of private universities. Improving educational opportunity and achievement in our K-12 schools underlies almost all goals.

Common Characteristics of These Challenges

Generally, the world scene today seems unsettled, yet these pervasive problems require steady and long-term commitments. The new world order involves a globalized economy; a cacophony of information, opinions and news; economic dislocation; competition for resources (energy, minerals, land, water); and many disenfranchised, desperate people. It seems more difficult for central governments to function, and while a globalized economy can make markets more efficient, not all problems seem amenable to purely market-based solutions.

Almost all of the major challenges that we now face will require commitments sustained over years or decades for humans to achieve their goals. For example, it took more than a decade of purposeful action to eradicate smallpox while similar efforts against polio have taken longer without yet achieving eradication. To significantly reduce dependence on fossil fuels through energy efficiency, renewable energy and nuclear power involves an agenda of decades of committed action. In 2009, Harold Shapiro, the chairman of our NAS/NRC report *America's Energy Future* presented the report to the U.S. Department of Energy. NAS member Steven Koonin received the report on behalf of the DOE and asked Professor Shapiro if there was any precedent in American history for the kind of dedicated national commitment commensurate with the requirements of *America's Energy Future*. Professor Shapiro said something like "possibly the creation of the Interstate Highway System". The point is that there are few precedents because it is difficult to maintain commitments for several decades.

An all-too-common reaction to the current array of contemporary and future global problems is to regard them as being beyond our ability to solve.

This array of problems can be discouraging and overwhelming to people who are aware of them, but surely those overarching problems will not be solved by people who are unaware of them.

I want to argue that we have the means to confront our problems. One reason for optimism is that many of them are science-centric, that is, their management or outright solutions will require either applied science or scientific discovery, or both.

I will argue that organizations and institutions will be essential in our efforts because our largest challenges need sustained commitment (adaptive management, iterations, updates, data, and yes, scientific curiosity and inspiration) and varied kinds of expertise, requirements which institutions can meet.

The Need for Common Goals

A recent newspaper column by David Brooks¹ struck me as containing a central point. We need common goals. Although Brooks was addressing the U.S. health-care management debate, it seems to me that the need for common goals applies to virtually all complicated, long-term problems where limits exist, demands are rising, where precedents are few or are too simple, and where wide expertise is needed. In such cases, one might wish to begin by assuming a simple path to solution (for example, employing a single technology) or by being guided by an economic or political ideology. However, current and future realities are likely to intervene, and empirical course correction (adaptive management) or new research discoveries will be needed. As we move ahead and involve our institutions and organizations (including governments) in large and more complex problems, we must begin with common goals. Goals can emerge gradually from a social or political consensus or more suddenly from insights of a few far-seeing people.

We Need Institutions and Organizations

Today's most troubling and daunting problems have common features: some of them arise from human numbers and resource exploitation; they require long-term commitments from separate sectors of society and diverse disciplines to solve; simple, unidimensional solutions are unlikely; and failure to solve them can lead to disasters. In some ways, the scales and complexities of our current and future problems are unprecedented, and it is likely that solutions will have to be iterative, by incorporating new findings and recognizing changing circumstances, and preserving flexibility along the way. In other words, scientific methods will be very valuable.

Institutions can enable the ideas and energies of individuals to have more impact and to sustain efforts in ways that individuals cannot. Good examples are the successful Green Revolution of research, field testing and realization of large increases in agricultural crop yields (led by the Rockefeller and Ford Foundations), major increases in attention and effort on behalf of K-12 education (led by the Carnegie Corporation of New York²), and current efforts to achieve more effective worldwide immunizations (led by the Gates Foundation).

Many examples of sustained governmental achievement are clear, such as the provision of clean and safe drinking water through science-based methods of purification, testing, delivery and monitoring by municipal, state and federal governments. Earlier I mentioned the creation of the Interstate Highway System. A number of people need to be reminded of the value of government. While it is clear that governmental institutions are essential, it is also clear that nongovernmental institutions are needed because elected leaders change, as does the popularity of issues and of preferred solutions.

In the scientific enterprise, we have societies that convene regular scientific conferences and publish journals in many fields. They also sponsor student scholarships and Congressional fellowships for advanced students, activities that are very worthwhile and difficult for an individual to do. Educational outreach efforts to enhance access to scientists and to careers, and to improve teaching are also given continuity and extra potency when organizations mount them along with individuals.

We must encourage our scientific and professional societies to become more active, not only in traditional activities but also in large-scale challenges that involve science. Preparing public statements on issues and committing to goals are initial steps toward solving large problems. For example, while a definitive history of the road to doubling the NIH budget has not been written, we know that FASEB³ and Research! America and other biological societies worked for years toward this goal. Issues that need continuing attention range from the conduct of science (opportunities for young scientists, ethics and integrity, data handling) to global ones such as water quality, agricultural security, energy supply and demand and many aspects of health.

In today's media-driven world, existing and new organizations can also serve as information resources where one can go to find reliable, responsible data and documents, on many specific phenomena and issues. Tracking progress toward long-term goals could be enabled by such information sources, with analysis and evaluation methods provided by social, physical and biological scientists. These information nodes can also illustrate the scientific method of using data and refining approaches, and introduce a scientific way of thinking. In any case, it is critical to measure

progress toward long-term goals including relevant government programs. Institutions are well-suited to this task.

Creating and supporting civic organizations is a strong American tradition⁴. A recommitment to this tradition will allow us to take on many of the current challenges that are too large or long lasting for individuals to address. Our agenda can become more ambitious again.

The National Academy of Sciences

Let me examine briefly how well the NAS and NAS members contribute institutional capability to identify, analyze and solve today's challenges.

The NAS has several missions⁵: (a) to validate scientific excellence, (b) to enhance the vitality of the scientific enterprise, (c) to guide public policy with science, and (d) to effectively communicate science.

Most of our work on validating scientific excellence (a) is accomplished in our annual election of new members and the awarding of NAS prizes, which can recognize contributions aimed at long-term challenges. Enhancing the vitality of the scientific enterprise (b) is clearly essential in any long-term effort to solve science-based problems. Publishing the *Proceedings of the National Academy of Sciences*, convening scientific meetings on specialized and interdisciplinary topics, and working to improve science education and its accessibility are relevant and essential.

A main part of our mission, to guide public policy with science (c), is central to societal problem solving. We are engaged continually in this mission, usually in partnership with the National Academy of Engineering and the Institute of Medicine through our operating arm, the National Research Council.

The final mission, to communicate the nature, values and judgments of science to governments and the public (d), is always important and especially so in a world that is seeking solutions while learning from new information and changing conditions.

Thus, the missions of the NAS position it well to serve as an enabling institution, as does the fact that NRC reports have earned respect for their high standards and for avoiding partisan approaches to current and continuing problems. Sustained efforts that have led to long term successes are the work of our Committee on National Statistics through its interactions with the U.S. Census Bureau and the entire federal statistical system. Over a long period of time, the NAS/NRC Transportation Research Board helped in the planning, financing, design and construction of the Interstate Highway System. In a different mode, our Committee on International Security and Arms Control has also dealt constructively with serious, vexing and continuing problems. In general, however, there is too little continuity of our work on persistent topics, in my opinion. There is more potential value in our NRC studies if we can construct more multi-disciplinary and longer term views from the component pieces of our individual reports.

A fundamental source of value of the NAS is its members. NAS members are respected for their expertise and their accomplishments — at their home institutions, nationally and internationally — and their voices and writings are influential. NAS members can be major forces in arriving at common goals for our nation, for selecting goals that are ambitious and in devising problem-solving strategies to be adopted by governments and by non-governmental institutions. NAS members can lend prestige to meritorious causes and can be very important in

choosing new leaders to carry on in the future and in supporting new leaders. It is important for NAS members to engage in the solution of long term issues, both for their direct contributions to solutions and to draw in the talents of other scientists.

Combining Ambition and Human Resources

In summary, we face an array of serious, continuing and emerging problems that are large-scale and pervasive. We are also in an era of diminished resources of governments and some loss of confidence in government, in a number of nations.

This combination of events has led, in some circles, to discouragement and to diminished views of the future. However, there are powerful resources from which solutions can be drawn, especially in those cases where the solutions to current and future problems are science-based. The general need for attention and commitment — sustained for approximately a human generation — can be met through organizations and institutions, and American precedent for creating and supporting such civic organizations is strong.

The National Academy of Sciences is itself such an institution and the ability of the NAS to rise to such challenges is substantial and can be enhanced. The restored and renovated NAS Building will be an active site as the NAS, NAE, IOM and the NRC convene experts and leaders to formulate goals, strategies and new research and to measure progress on current and future challenges. The NAS can rally the scientific community to attack large goals and, over time, the NAS can demonstrate the value of the scientific method and of science in achieving those goals. Let us be ambitious on behalf of our Academy, our nation and the world.

NOTES AND REFERENCES

1. “Step to the Center”, *New York Times*, March 27, 2010, by David Brooks.
2. Carnegie Corporation of New York (CCNY) also provided a gift that enabled NAS to build our Constitution Avenue building in 1924.
Disclosure: I am currently a trustee of CCNY.
3. FASEB is the Federation of American Societies for Experimental Biology.
4. See for example, *Bowling Alone* by Robert D. Putnam, Simon & Schuster, New York, 2000, 541 pp.
5. “The Mission of NAS: Timeless and Timely”, speech to 143rd Meeting of the National Academy of Sciences, April 24, 2006, Ralph J. Cicerone.